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STAFF MEMO

SMOKING-RELATED DEATHS AND FINANCIAL COSTS

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TABLE OF CONTENTS

SUMMARY.....1

INTRODUCTION.....6

PREVIOUS ESTIMATES OF SMOKING-RELATED DISEASE.....8

PREVIOUS ESTIMATES OF SMOKING-RELATED DISEASE COSTS.....11

OTA'S ESTIMATES.....21
Smoking-related Mortality.....21
Cancer Deaths.....22
Chronic Obstructive Lung Disease Deaths.....29
Cardiovascular Disease Deaths.....33
Summary of OTA Estimates of Smoking-related Deaths...43
Life-years Lost and Probability of Early Death.....43
Smoking-related Disease Costs.....48

FUTURE COSTS IF SMOKING IS REDUCED.....56

ACKNOWLEDGEMENTS.....63

REFERENCES.....64

SUMMARY

Smoking is associated with a number of diseases, including cancer, heart disease, and chronic lung disease. This OTA Staff Memorandum reviews previous estimates of the extent of smoking-related disease and the financial costs associated with treating smoking-related disease. At the request of the Subcommittee on Health of the House Ways and Means Committee, OTA has developed estimates of the smoking-related health care costs borne by the government through the Medicare and Medicaid programs.

For this analysis, OTA has focused on the three major categories of smoking-related disease--cancers, cardiovascular disease, and respiratory system disease. These account for the vast majority of smoking-related deaths. The basic data for many of OTA's calculations are from an American Cancer Society health study of nearly one million Americans for the years 1959 to 1965. Using the death rates for cancer, cardiovascular disease, and chronic lung disease for non-smokers who were enrolled in that study it is possible to calculate the expected number of deaths that would occur if no one in the U.S. smoked. Subtracting that expected number from the number that actually occurred yields an estimate of the deaths that may be attributed to smoking.

Table 1 summarizes OTA's numerical estimates of smoking-related deaths. About 139,000 people died in 1982 from smoking-related *cancers*--about 32 percent of all cancer deaths. (This represents an increase of about 17,000 cancer deaths from that previously estimated using 1978 mortality data by

Table 1

Smoking-related Deaths

Summary

DEATHS (in 1982)

	Middle Estimate		Range
Cancer	139,000	(32% of cancer deaths)	89,000-174,000
Cardiovasular disease	123,000	(13% of cardiovascular disease deaths)	48,000-170,000
Chronic obstructive lung disease	52,000	(88% of chronic lung disease deaths)	49,000- 54,000
Total of above	314,000	(16% of deaths from all causes)	186,000-398,000

LIFE-YEARS LOST (in 1982)

Total person-years lost	5,300,000
Years lost before age 65	1,200,000

Source: Office of Technology Assessment

Richard Doll and Richard Peto.) About 123,000 are estimated to have died from *cardiovascular disease* associated with smoking. And 52,000 died in 1982 from smoking-related non-cancerous *chronic lung disease*. The middle estimate of the total death toll from these three disease categories amounts to nearly 320,000 deaths, with a range between OTA's low and high estimates of 186,000 to 398,000 deaths in 1982. This range is broad, indicating some uncertainty about the exact magnitude of the smoking toll. But it should be emphasized that the even the lower estimate is substantially greater than zero.

Life-years lost is one measure of premature mortality. For 1982, OTA estimates that about 5.3 million person-years were lost from smoking-related disease. Of these years, 1.2 million are lost before the age of 65.

Previous estimates of the health care costs of smoking, adjusted for inflation, range from $8.6 to $27.4 billion (in 1985 dollars). These estimates have been based on apportioning health care costs by the fraction of deaths that are associated with smoking.

Using the same methodology, OTA estimates that in 1985 the U.S. health care system will spend between $12 billion and $35 billion to treat smoking-related diseases. OTA's middle estimate is health care costs of about $22 billion. This amounts to about 72 cents for each pack of cigarettes sold in the U.S. Estimated Medicare costs are $1.7 billion to $5.4 billion, while Medicaid costs amount to $0.3 to $1.1 billion. After subtracting the State share of Medicaid costs and adding in other Federal programs that provide health care to the elderly, the estimate is that the Federal government pays between $2.1 billion and $6.6 billion for treating smoking-related disease. OTA's middle estimate is that the Federal costs amount to about $4.2 billion in 1985 or about 14 cents for each pack of cigarettes.

Table 2

Smoking-related Financial Costs
Summary

HEALTH CARE COSTS (in 1985 dollars)

	Middle Estimate	Per Pack	Range	Per Pack
Total health care costs -	$22 billion	$ .72	$12-35 billion	$ .38-$1.17
Medicare costs* -	$3.4 billion	$ .11	$1.7-5.4 billion	$ .06-$ .18
Medicaid costs* -	$0.7 billion	$ .02	$0.3-1.1 billion	$ .00-$ .04
Federal govt. costs for smoking-related health care*	$4.2 billion	$ .14	$2.1-6.6 billion	$ .07-$ .22

LOST PRODUCTIVITY COSTS (in 1985 dollars)

	Middle Estimate	Per Pack	Range	Per Pack
Total lost earnings	$43 billion	$1.45	$27-61 billion	$ .90-$2.02

TOTAL OF HEALTH CARE AND LOST PRODUCTIVITY COSTS (in 1985 dollars)

	Middle Estimate	Per Pack	Range	Per Pack
Total costs	$65 billion	$2.17	$38-$95 billion	$1.27-$3.17

Source: Office of Technology Assessment

* Government program cost estimates are only for persons aged 65 and over.

Smoking-related disease also results in productivity losses for the economy. For 1985, OTA estimates that these fall in the range of between $27 and $61 billion, with a middle estimate of $43 billion. The middle estimate amounts to about $1.45 for each pack of cigarettes sold. The total of smoking-related health care costs and lost productivity costs amounts to between $39 and $96 billion, with a middle estimate of $65 billion. The middle estimate equals $2.17 per pack of cigarettes.

This analysis does not discuss in detail all of the effects that smoking has on the economy or all government programs. For simplicity, only the mortality toll of smoking and its effects on direct medical care spending and the indirect costs of lost productivity were estimated.

Currently smoking currently leads to a real and substantial loss of life and significant health care spending. Reduction or elimination of smoking would improve health and extend longevity, but it may not lead to savings in health care costs. In fact, reduction in the prevalence of smoking could lead to future increases in total medical spending, in the costs of the Medicare program, and in the budgets of the Social Security program and other government programs. OTA has not estimated what these hypothetical effects might be. Research on this question is still in its infancy and it is not clear exactly what effect reduced smoking will have on future health care costs.

But even if reduced smoking leads to increased costs in future years, it will also lead to improved health and additional years of life for thousands currently dying of smoking-related disease. Relatively modest expenditures might lead to large improvements in longevity and thus represent cost-effective ways of improving health and preventing premature death.

INTRODUCTION

Numerous epidemiologic studies have shown that the use of cigarettes, cigars, and pipes is associated with a diverse group of diseases, including cancers of the lung, lip and mouth, larynx, esophagus, pancreas and bladder; heart disease; and chronic lung disease. Nearly all researchers in this field are now convinced that smoking causes disease and premature death.[1]

Based on preliminary data from the 1983 Health Interview Survey, there are about 50 million smokers in the U.S. In 1984, about 600 billion cigarettes, or about 30 billion packs, were sold. The retail sales of these cigarettes amounted to an estimated $28.8 billion. Sales of cigars, chewing tobacco, snuff, and loose tobacco (such as for pipes) added another $1.9 billion for total tobacco sales of $30.7 billion (USDA, 1985).

The Subcommittee on Health of the House Ways and Means Committee has asked that OTA prepare an analysis of the financial costs of smoking to society, and the costs borne by the Medicare and Medicaid programs. This analysis includes a review of previous estimates of the costs of smoking-related disease. Past cost estimates have generally used the fraction of mortality related to smoking (attributable risk) and then multiplied that fraction times the costs of a particular illness category. The estimates in

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[1] Comprehensive reviews of the scientific literature on smoking and health can be found in the various Surgeon General's reports (listed in the bibliography under U.S. Dept. of Health, Education, and Welfare and U.S. Dept. of Health and Human Services, Office on Smoking and Health). A few still dispute the consensus in the epidemiologic and medical communities concerning the links between smoking and disease. See, for example, testimony presented at hearings concerning the Smoking Prevention Act (U.S. Congress, 1982, 1983), and comments to OTA (Chilcote, 1985; Sterling, et al, 1985).

this paper will follow the same general approach. The first step in calculating costs is to estimate the number of deaths related to smoking in each of the three major disease categories that has been associated with smoking--cancers, heart disease, and chronic respiratory disease.

Unlike most previous estimates of smoking-related deaths, OTA's estimates will provide the age distribution of smoking-related deaths. This also permits calculation of the number of life-years lost due to smoking-related disease. "Life-years saved" is increasingly being used to measure the effects of health interventions. After all, death is inevitable for each of us; but the reduction of the incidence of premature death is an achievable goal. Life-years lost is one measure of the extent of premature mortality.

The second step is to apply the estimates of the smoking-related fraction of mortality to the health care costs for each major disease category. Thus, in the first step an estimate will be prepared of the fractions of cancers, cardiovascular disease, and respiratory system disease that are related to smoking. In the second step, those fractions are applied to the total health care costs for each class of disease. The third step of this analysis estimates the share of smoking-related health care costs for the elderly paid for by government programs. Finally, OTA presents estimates of the lost productivity costs for people who are ill and disabled or who die prematurely from each major type of smoking-related disease.

This Staff Memorandum will concentrate on the mortality associated with smoking and on the health care costs and lost productivity costs that may be attributed to smoking. Thus, this analysis leaves out a number of important topics. The production and sale of cigarettes and other tobacco products affects several sectors of the economy, providing jobs and profits. The sale

of cigarettes also yields significant tax revenues for the Federal, state, and local governments. The effects that measures to reduce smoking would have on the U.S. economy and government tax revenues will not be discussed in this Memo.

In general, throughout this Staff Memorandum, OTA has been "conservative" in its choice of assumptions. Estimates of mortality are limited to only the three major groups of smoking-related disease. The assumptions employed in this analysis will, in most cases, lead to underestimates of the extent of smoking-related disease. The estimates presented here should thus be considered minimum estimates.

PREVIOUS ESTIMATES OF SMOKING-RELATED DISEASE

Table 3 presents the range of attributable risk estimates for smoking-related disease. "Attributable risk" is a concept from epidemiology. Put most simply, attributable risk is the fraction or percentage of disease that is associated with a specified risk factor and that would not have occurred in the absence of the risk factor. In this case, the risk factor is smoking of tobacco products, most generally cigarettes. As used in this paper, the attributable risk for smoking is the percentage of deaths in a given year that would not have occurred if no one had smoked.

The fraction of major diseases attributed to smoking ranges from 20 to 40 percent of cancers, 11 to 25 percent of cardiovascular disease, and 20 to 40 percent of all respiratory system disease (including 80-90 percent of

Table 3

Previous estimates of attributable risks for smoking[1]

Source	Cancer Deaths	Cardio-vascular Disease Deaths	Respir-atory Disease Deaths	Diges-tive Disease Deaths	Deaths from Injuries	Peri-natal Deaths	Total Smoking-Related Deaths	Year estimate applies to
Kristein (1977)	30%	15%	33%	--	--	--	--	
Luce & Schweitzer (1978)	20%	25%	40%	--	1%	--	--	(1976)
Richter & Gori (1980)	--[6]	30%[2]	85%[3]	--	--	--	--	
Rice & Hodgson (1983)	22%	16%	20%	16%	--	--	290,313	(1980)
Leu & Schaub (1983b)	--[7]	20%/6%[1,2]	67%/16%[1,3]	--	--	--	--	
Ravenholt (1984)	35%	24%	57%	39%	4%	9%	485,000	(1980)
Minn. Health Dept. (1984)	24%	11%	39%	8%	1%	13%	5,000[9]	(1981)
Lewit (1984)	20-30%	20%	40%	--	--	--	--	(1964-84)
Enstrom (1979)	38%[10]	--	--	--	--	--	--	
Hammond & Seidman (1980)	35%/5%[1]	--	--	--	--	--	--	(1967-71)
Doll & Peto (1981)	30%	--	--	--	--	--	122,048[5]	(1978)
Whyte (1976)	--	16%[2,8]	--	--	--	--	--	
Surgeon General (1979)	--	--	--	--	--	--	346,000	
Surgeon General (1982)	30%	--	--	--	--	--	129,000[5]	(1982)
Surgeon General (1983)	--	up to 30%[2]	--	--	--	--	170,000[2]	(1983)
Surgeon General (1984)	--	--	80-90%[4]	--	--	--	50,000[4]	(1983)
American Cancer Society (1985)	29%	--	--	--	--	--	320,000	(1985)

Source: Office of Technology Assessment, based on cited sources.

Table 3 (continued)

Previous estimates of attributable risks for smoking[1]

NOTES

N.B.: All percentages have been rounded to the nearest whole number percent. Dashes indicate that no estimate was made for that category. Unless indicated otherwise, attributable risk estimates are for males and females combined.

[1] First figure is for males; the second for females.

[2] Heart disease deaths only.

[3] Bronchitis & emphysema deaths only.

[4] Chronic obstructive lung disease deaths only.

[5] Cancer deaths only.

[6] Richter & Gori gave no overall percentage for cancer deaths. Site-specific cancer estimates were:
Male: Trachea, bronchus, & lung--90%, Oral cavity--70%, Larynx--50%, Espohagus--40%, Pancreas--35%, Bladder--50%, Kidney--25%

Female: Trachea, bronchus, & lung--85%, Oral cavity--70%, Larynx--50%, Espohagus--20%. Pancreas--35%, Bladder--30%, Kidney--15%

They also estimated that 33% of arteriosclerosis in both males and females to be attributable to smoking.

[7] Leu & Schaub gave no overall percentage for cancer deaths. Site-specific cancer estimates were:
Male: Trachea, bronchus, & lung--83%, Oral cavity--40%, Larynx--47%, Esophagus--34%, Pancreas--44%, Bladder--30%.
Female: Trachea, bronchus, & lung--22%, Oral cavity--19%, Larynx--20%, Esophagus--15%, Pancreas--0%, Bladder--0%.
They also attributed 45% of male aortic aneurysm deaths, and 53% of male and 18% of deaths from other peripheral vascular disease to smoking.

[8] Whyte also attributed 24% of first coronary events to smoking.

[9] Deaths in Minnesota only.

[10] Estimated by Doll & Peto (1981) from tables in Enstrom (1979)

chronic obstructive lung disease)[2]. Some analysts have also attributed to smoking some deaths from digestive system disease (e.g. stomach and duodenal ulcers), accidental injuries (e.g. fires), and perinatal mortality (mothers who smoke during pregnancy tend to have higher rates of miscarriages and lower birthweight babies). In general, a factor of 2 or 3 separates the lower end of each range from the upper. But because the number of total deaths in each of these categories is quite large, the difference between an estimate based on the lower bound and one based on an upper can amount to tens of thousands of deaths.

Also shown in Table 3 are estimates of the number of deaths from smoking-related disease. These range from about 300,000 deaths each year to 485,000. The Surgeon General's reports on smoking have, in the last few years, presented estimates of 129,000 deaths from cancer, 170,000 deaths from heart disease, and 50,000 deaths from chronic obstructive lung disease. Together, these total to about 350,000 deaths annually.

PREVIOUS ESTIMATES OF SMOKING-RELATED DISEASE COSTS

Generally, two broad categories of costs--direct and indirect--have been considered in making estimates of disease costs. The direct costs are goods and services that are used in caring for and treating those with disease. Usually, the only direct costs that are estimated are those directly associated with medical care. Indirect costs are generally represented by the lost productivity of those who suffer from disease. Lost productivity is most

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[2] Chronic obstructive lung disease is a general category of disease that includes chronic bronchitis, emphysema, and asthma. Physicians completing death certificates now more commonly use this general category, rather than referring specifically to bronchitis or emphysema.

commonly measured using lost wages, often with some adjustment for the household services provided by housewives, and usually includes the lost productivity from work loss during illness and future earnings lost due to premature death.

The literature on the cost of illness has used two different approaches to estimate direct and indirect costs. In the prevalence approach, all medical costs are attributed to the year in which the money is actually spent. In the incidence approach, present and future medical costs[3] are attributed to the year in which the disease first becomes manifest. Thus, if the course of a disease involves medical treatment over three different years before the patient dies, the prevalence approach would assign the costs separately to each year. The incidence approach, on the other hand, would calculate a present value for the stream of costs over the three-year period, and assign that single sum to the first year the disease was treated. For diseases that involve less than one year of treatment, the two approaches are essentially the same.

For indirect costs, the prevalence approach assigns the costs of lost productivity due to morbidity to the year in which the productivity is lost. In the prevalence approach, the future earnings lost due to mortality are discounted and assigned to the year of death. In the incidence approach, all indirect costs due to morbidity and the lost future earnings due to mortality are discounted and assigned to the year the disease is first manifest.

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[3] These are expressed as present values, i.e. they have been *discounted* to take account of the time value of money. Even in an economy with stable prices, a dollar today is worth more than a dollar tomorrow. This is so because with a dollar today, an investment can be made to earn a return and because people prefer present consumption to future consumption. The appropriate rate of interest to use for discounting future effects, however, has been a matter of some dispute.

The landmark work of Rice and her colleagues (Rice, 1967; Cooper & Rice, 1976), which discussed the costs of all diseases, used the prevalence approach, as does the most recent update of this method by Hodgson and Kopstein (Hodgson & Kopstein, 1984). Only recently have researchers tried to implement the incidence approach. For example, Hartunian and colleagues, have measured and compared the costs of coronary heart disease, stroke, cancer, and motor vehicle injuries (Hartunian, et al., 1981).

Table 4 presents previous estimates of the costs of smoking. Hedrick, who prepared one of the earliest estimates, used the results of a study of the costs of smoking in Canada. The estimated cost of $278 million associated with lung cancer, coronary heart disease, chronic bronchitis and emphysema was increased by 50 percent to take account of diseases not included. After adding in estimates of the costs of morbidity and of fires (from the Canadian study), the total amounted to $526.5 million. An estimate of U.S. costs was made by multiplying this figure for Canadian costs by 10--the ratio of the U.S. Gross National Product to that of Canada (Hedrick, 1971).

The most commonly cited estimate of the costs of smoking is one prepared by Luce and Schweitzer (1978). Following the prevalence approach, they used the Cooper and Rice (1976) cost of illness statistics for the year 1972, inflated them to 1975 dollars,[4] and then attributed 20 percent of the costs of neoplasms, 25 percent of circulatory system disease costs, 40 percent of respiratory system disease costs, and 1.1 percent of the health care costs

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[4] Using the medical care component of the Consumer Price Index (for medical costs) and the Gross National Product Implicit Price Deflator (for lost earnings.

Table 4

Previous Estimates
U.S. Smoking-related Disease Costs
(in billions of dollars)

Source	Direct Health Care Costs (year)	Indirect Productivity Costs (year)	Direct Health Care Costs (1985)[1]	Indirect Productivity Costs (1985)[2]
Hedrick (1971)	--	5.3 (1966)[3]	--	--
Williams & Justus (1974)	4.2 (1970)[4]	--	23.9	--
Freeman, et al. (1976)	1.5 (1970)[5]	--	8.6	--
Luce & Schweitzer (1978)	8.2 (1976)	19.1 (1976)	23.0	33.6
Califano (1979)	5-8 (1979)	12-18 (1979)	10-16	17-25
Wolfe (1977)	7.1 (1976)	11.8 (1976)	19.9	20.8
Kristein (1977)	5.2 (1975)	15.1 (1975)	16.6	28.5
Rice & Hodgson (1983)	16.1 (1980)	26.1 (1980)	27.4	34.3
Lewit (1985)	14.2 (average 1964-1983, in 1983 dollars)	32.4	16.9 (average 1964-1983)	35.6
Lewit (1985)	284.5 (total 1964-1983, in 1983 dollars)	647.3	338.6 (total 1964-1983)	712.0

Source: Office of Technology Assessment, based on cited sources.

Table 4 (continued)

Previous Estimates
U.S. Smoking-related Disease Costs

NOTES

[1] Adjusted to 1985 dollars using the change in total expenditures for personal health care in the U.S. Values for 1970 to 1983 were taken from Table 2, "National health expenditures, by type of expenditure," in R.M. Gibson, K.R. Levit, H. Lazenby, & D.R. Waldo, "National Health Expenditures, 1983," Health Care Financing Review 6(2):1-29, Winter 1984. The value used for 1985 ($372.8 billion) is the latest available projection for personal health care expenditures from the Health Care Financing Administration (R. Arnett, personal communication, 1985).

[2] Adjusted to 1985 dollars using the change in average weekly earnings. Values for 1970 to 1983 were taken from the data on hours and earnings of production workers on private, nonagricultrual payrolls published in Employment and Earnings, March 1985, Table C-1. The value for 1985 was estimated, assuming a 5 percent increase in average weekly earnings from 1984 to 1985.

[3] Direct and indirect costs were not presented separately.

[4] Respiratory disease only.

[5] Emphysema only.

and lost earnings from accidents (for the fire-related injuries).[5], The total estimated health care costs were about $8.2 billion, which, according to their calculations represented 7.8 percent of the total health care expenditures in the U.S. The indirect costs of lost earnings amounted to $6.2 billion for morbidity, and 12.9 billion for mortality. Their total, including property losses, was $27.5 billion.[6]

Then HHS Secretary Joseph Califano, in the forward to the 1979 Surgeon General's report on smoking, estimated that smoking resulted in $5-8 billion in health care expenses--2.5 to 4 percent of the Nation's health care costs of $205 billion. Lost productivity, wages, and absenteeism due to smoking related illness were estimated to amount to $12-18 billion.

Sidney Wolfe estimated the morbidity, mortality, and direct health care costs of smoking to be $18.94 billion in 1976. The morbidity costs were calculated using the results of a Department of Health, Education, and Welfare study that found that 19 percent of days lost from work were related to smoking. This resulted in a figure of $2.96 billion. To this he added $1.18 billion to account for morbidity among those unable to work, for a total morbidity cost of $4.14 billion. Mortality costs and direct medical care costs were estimated using attibutable risks derived from a National Science Foundation report. Mortality costs amounted to $7.7 billion. Direct health care costs were estimated to be $.93 billion for cancers, $1.99 billion for cardiovascular disease, and $1.67 billion for respiratory disease in 1972. An adjustment for the increase in medical costs between 1972 and 1976 resulted in an estimate of $7.1 billion for 1976 (Wolfe, 1977).

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[5] They also included and estimate of the value of property lost in smoking-related fires.

[6] Including $176 million for property costs due to fires.

Marvin Kristein derived his estimate of health care costs from information that implied that smokers of one or more packs per day had a 50 percent greater hospitalization rate than non-smokers. Using data on the number of such smokers in 1975, and the total national spending on health care, he calculated that smokers used $5.2 billion in health care services in 1975. He used a National Center for Health Statistics estimate that 77 million days were lost from work in 1965 due to cigarette smoking. These he valued at $40 per day to generate an estimate of $3.1 billion in lost productivity due to morbidity. Using an estimate that 300,000 deaths in 1975 were associated with smoking, he calculated that the lost earnings amounted to $12 billion (Kristein, 1977).

In a second article, Kristein estimated the costs of smoking borne by business firms for the "average" smoker. He included estimates of the costs of health insurance, fire losses, workers' compensation, absenteeism, productivity losses, and involuntary exposure to tobacco smoke. Added together, these amounted to between $336 and $601 (1980 dollars) per smoker (Kristein, 1983).

Oster and colleagues estimated the costs of smoking-related cases of lung cancer, coronary heart disease, and chronic obstructive pulmonary disease using the incidence approach (Oster, et al, 1984). They, however, only estimated the average costs for age and sex-specific groups of smokers. For example, men aged 40-44 who smoke more than two packs per day incur, on average, a discounted total of lifetime costs of $56,670 in direct medical care costs and indirect costs due to lost productivity compared to non-smokers

of the same age and sex.[7] They did not attempt to aggregate these group specific costs for all of society.

Rice and Hodgson (1983) have also developed estimates for the costs of smoking, using the prevalence approach. They developed more detailed estimates of the fractions of mortality associated with smoking than the ones used by Luce and Schweitzer. The result was that they attributed about 22 percent of cancer deaths, 16 percent of circulatory system deaths, 20 percent of respiratory system deaths, 16 percent of digestive system deaths, and 3.5 percent of infectious and parasitic disease deaths (specifically, tuberculosis) to smoking. These fractions were then multiplied by the costs of medical care and lost productivity for each of these categories. In 1980 dollars, the direct medical costs amounted to $16.1 billion, the indirect costs of morbidity were about $6.9 billion, and the indirect costs of mortality, about $19.2 billion. The total costs were thus about $42.2 billion (Rice and Hodgson, 1983).

The Minnesota Department of Health has developed estimates of the costs of smoking-related disease for the state of Minnesota. Their approach is generally the same as that used by Rice and Hodgson, with the addition of specific information on the prevalence of smoking in Minnesota. They estimate that the direct medical care cost of smoking-related disease in Minnesota in 1983 was $374.6 million and the indirect cost of lost income due to premature death was $303.3 million. These total to $677.9 million or about $807 per year for each smoker in the state and $1.48 for each pack of cigarettes sold

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[7] Costs are in 1980 dollars and the discount rate used was 3 percent. For women smokers of the same age group, the costs are lower, $19,000, largely because the indirect costs are based on the average earnings of women, which are substantially less than those of men.

in Minnesota (Minn. Dept. of Health, 1984).

Kruckemeyer, et al., developed estimates for the state of Missouri. They estimate that the state of Missouri spent about $10 million for smoking-related disease in Missouri in 1981, while Federal programs incurred about $212 million. Their analysis also shows that while the state government received $61 million in tobacco-related revenue, the Federal government received only $55 million from tobacco sales in Missouri. Thus, they estimate, that a Federal excise tax would need to be about 32 cents per pack in order to cover just the direct costs incurred by the Federal government for smoking-related disease in Missouri (Kruckemeyer, et al).

Table 4 also presents these estimated costs with adjustments for the effects of inflation since these estimates were made. After this adjustment, most of these estimates appear to fall within a limited range: $15 to $30 billion in direct health care costs, and $25 to $40 billion in indirect productivity losses (in 1985 dollars). In part, the consistency of these estimates arises from the application of similar methods to the same basic data sources.

In addition, researchers have used other information to compare explicitly smokers and non-smokers in their use of medical services and the frequency of lost worktime and disability. Based on data from the 1964-5 and 1974 National Health Interview Surveys, the Surgeon General's 1979 report on Smoking and Health found that current cigarette smokers tend to report more chronic conditions, such as emphysema and heart disease, than persons who never smoked. The incidence of acute conditions, such as influenza, was higher among smokers than among non-smokers. Current smokers also reported more work-loss days and bed-disability days than did the non-smokers.

Finally, current smokers and former smokers reported more hospitalizations than non-smokers (DHHS, 1979). Rice and Hodgson are now conducting an analysis of the data collected in the 1979 National Health Interview survey. Their preliminary analysis finds that compared to persons who have never smoked, current and former smokers report 27 percent more days of restricted activity, 16 percent more bed disability, and 32 percent more work loss days. According to these data, smokers also use more medical services. They report about 12 percent more physician visits and 22 percent more hospital days for each 100 persons per year (T. Hodgson & D. Rice, personal communication, 1985).

Ashford conducted a large survey of the use of medical services in the city of Exeter in the United Kingdom and found that up to about the age of 60, male smokers consistently had more contacts with their doctors than did non-smokers. The amount of the difference varied by age group, but typically was about 25 percent more than for non-smokers. Above the age of 60, however, the non-smokers tended to use more medical services. In part, this was believed to occur because by that age many of the smokers who were ill from smoking-related disease had already died. For hospital services, the smokers had a higher average length of stay in the hospital than did the non-smokers (Ashford, 1973).

Vogt and Schweitzer examined data collected from the Oregon region of the Kaiser-Permanente Medical Care Program--a Health Maintenance Organization (HMO). They observed that smokers used 20 percent more inpatient services than those who had never smoked, but that this difference "did not quite reach statistical significance." Smokers aged 45-64 did have significantly more hospitalizations for influenza and respiratory infections than did never

smokers. In responses to a survey question, smokers' assessments of their personal health were worse than the self-assessments of never smokers. Finally, they found that those who had never smoked used more outpatient, preventive medical services than did smokers, and were more likely to use outpatient medical care for minor illnesses (Vogt & Schweitzer, 1984). One important limitation to these results is the fact that their data were drawn from the experience of one particular HMO, and thus may not be representative of the entire U.S. population.

OTA'S ESTIMATES

The following discussion outlines OTA's methods for estimating the smoking-related mortality, the life-years lost, the direct and indirect social costs of smoking, the health care costs of smoking, and the costs incurred by Medicare and Medicaid for smoking-related disease. The results of these calculations are presented in a series of summary tables.[8]

Smoking-related Mortality

Table 3 presents previous estimates of the percentage of mortality in different disease categories that have been related to smoking. Some of these categories are less clearly associated with smoking than other categories. In part this is because for some there are important factors that may confound the associations between smoking and disease. For example, smokers also tend

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[8] Details of these calculations are included in a supplemental appendix, which is available on request.

to be relatively heavy drinkers of alcoholic beverages. Thus an apparent excess of disease in smokers may not be because of the use of tobacco, but due to the consumption of alcohol. Smokers as a group have a higher incidence of cirrhosis of the liver and ulcers. This excess of liver cirrhosis is probably due to consumption of alcohol. Ulcers may be independently associated with smoking, but for this analysis, both cirrhosis and ulcers will be excluded.

Women who smoke during pregnancy tend to have higher rates of miscarriage and their live-born babies weigh less than the average for the babies of non-smokers. There is also some evidence that children of smokers have more episodes of respiratory illness than do children of non-smokers. Burning cigarettes also start fires--fires that take an estimated 2,500 lives each year and lead to substantial property damage. Finally, non-smokers who are exposed to cigarette smoke ("passive smoking") may have an increased risk of disease compared to people not exposed to tobacco smoke. For simplicity, however, these categories are excluded from this analysis.

Instead, OTA has focused on the three major categories of smoking-related disease--cancers, cardiovascular disease, and respiratory system disease. These account for the vast majority of smoking-related deaths

Cancer Deaths

OTA's estimates for smoking-related cancer deaths in 1982 include only the cancer sites most clearly associated with smoking: the respiratory system (most particularly the lung); lip, oral cavity, and pharynx; esophagus; pancreas; and bladder. The method is identical to the method used by Doll and Peto to generate their estimate that about 30 percent of cancer deaths in the U.S. in 1978 were associated with smoking (Doll & Peto, 1981).[9]

Their method used the mortality rates for non-smokers from the large American Cancer Society (ACS) study (often referred to as the "25-state study" or the "million person study") that was conducted from 1959 to 1965. The age-specific mortality rates for non-smokers (from Garfinkle, 1980) are multiplied by the number of people in each age and sex specific population group. The result of that multiplication is an estimate of the "expected" number of deaths that would have occurred in a given year if everyone had the mortality experience of the non-smokers in the ACS study. This "expected" number is then subtracted from the number of deaths that actually occurred. The difference is attributed to smoking. The number of deaths for each type of cancer is taken directly from the Vital Statistics data published by the National Center for Health Statistics (NCHS). The NCHS data are based on the information about the "underlying" cause of death supplied on death certificates by physicians. The "attributable risk," the fraction of deaths if no one in the U.S. population had smoked is calculated by dividing the number of "excess" deaths by the total number of deaths.[10]

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[9] Doll and Peto prepared their estimates under contract to OTA. Their report was the basis for part of the OTA assessment of *Technologies for Determining Cancer Risks from the Environment*. The Doll and Peto report itself was later published in the *Journal of the National Cancer Institute* and republished as a book by Oxford University Press.

[10] This is not the only method for developing attributable risk estimates. In fact, in the discussion on heart disease deaths, the calculations use both this method (which is based on the deaths rates for non-smokers) and a second method, based on smoking prevalence and the estimated mortality ratios for smokers and non-smokers. The first method has the advantage of being able to allow for changes in smoking habits automatically (e.g. the shift to smoking lower tar cigarettes) and makes fewer assumptions about how well the smokers and the non-smokers in the original epidemiologic study population represent those in the general U.S. population. Of course, estimates based on non-smoker rates implicitly assume that all of the observed excess of a specified cause of death is due to smoking and that the rates for non-smokers from the ACS study are representative of the rates for all U.S. non-smokers.

In addition to the five major sites (respiratory system; lip, oral cavity, and pharynx; esophagus; pancreas; and bladder), Doll and Peto also attributed a relatively small number of cancers at other specified sites to smoking. These include some sites that may be associated with tobacco, such as kidney cancers, and others that may include some misdiagnosed cancers (for example, some "stomach" and "liver" cancers may be misdiagnosed pancreatic cancers). Doll and Peto included 5,000 male and 1,000 female cancer deaths for these other sites. The figures of 5,000 and 1,000 are also used for OTA's estimates.

They also included a share of the cancers reported to NCHS without information on the specific site, by assuming that the fraction of smoking-related cancer deaths at unspecified sites was the same as that estimated for the specified sites. To allow for the possibility that the non-smokers in the ACS study were less exposed to alcohol or other causes of upper respiratory or digestive system cancers than were non-smokers in the entire U.S. population, Doll and Peto doubled the number of deaths from cancers of the mouth, pharynx, larynx, and esophagus expected in non-smokers. OTA's estimates also include this adjustment.

Table 5 totals the results of the calculations. Overall, about 32 percent of all cancer deaths in 1982 are attributed to smoking, compared to 30 percent in 1978. The increase from 1978 to 1982 amounts to an additional 17,000 deaths per year from smoking-related cancers. The increasing toll matches Doll and Peto's prediction that smoking-related cancer deaths would increase by two or three percentage points by the mid-1980s (Doll & Peto, 1981).

Table 5

Smoking-related Cancer Deaths[1]
Total for all sites

United States, Estimates for 1982

Sex & Age Group	All Cancer Deaths (#)	Smoking-Related (#)	Smoking-Related (%)
Male - ages under 65	84,965	42,000	50%
Male - ages 65+	148,862	61,000	41%
Male - all ages	233,864	103,000	44%
Female - ages under 65	74,484	17,000	23%
Female - ages 65+	125,420	19,000	15%
Female - all ages	199,931	36,000	18%
Both Sexes - all ages[2]	433,795	139,000	32%

Source: Office of Technology Assessment

N.B. Estimates of smoking related deaths have been rounded to the nearest thousand.

[1] Based on calculations presented in Appendix Tables A-1 and A-2.

[2] Total for all ages includes deaths recorded without information on age.

The increasing toll is the direct result of the large increases in the prevalence of smoking that occurred during the 1940s, 1950s and the first half of the 1960s. Figure 1 illustrates the increase in per capita consumption of cigarettes from 1920 to 1960 and the increase in the respiratory system cancer death rate from 1940 to 1979. The rise in cigarette consumption is paralleled by rising death rates 20 years later (Kristein, 1984). Per capita consumption reached its peak in the mid-1960s and has shown a small decline since then. The effects of this reduction should be seen in cancer death rates in future years.

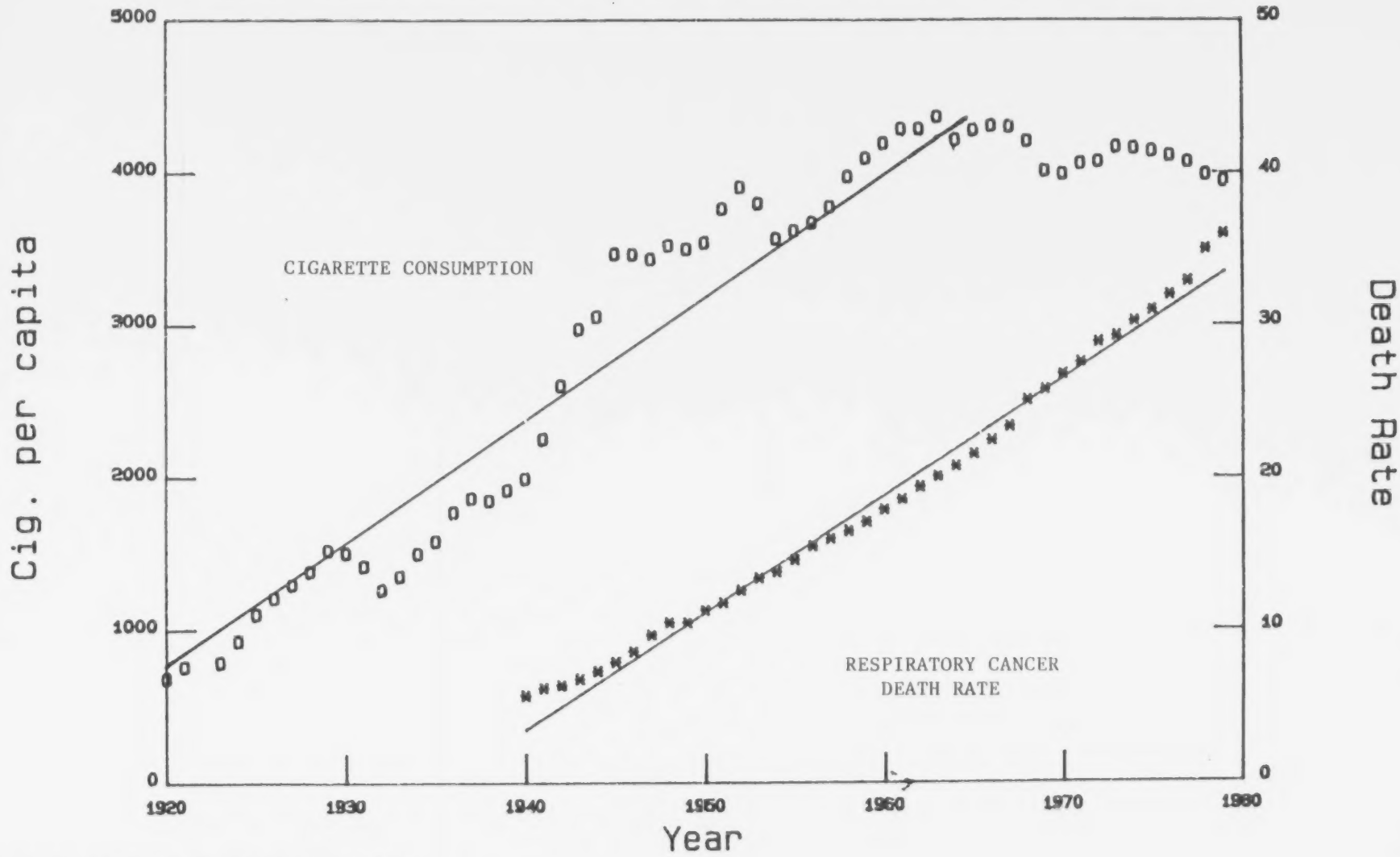
Forty-four percent of cancer mortality in men is related to smoking, and about 18 percent of female cancer mortality. The difference between the two sexes is largely due to the greater prevalence of smoking, higher per capita consumption of cigarettes, and greater degree of inhalation among men compared to women. It should be noted that the number of smoking-related cancer deaths among women is still rising rapidly. Sometime soon, perhaps this year in fact, lung cancer will overtake breast cancer as the leading cause of cancer deaths among women--fulfilling a prediction made years ago.

There are also significant age differences in the attributable risks for cancer. Fifty percent of male cancer deaths under the age of 65 are related to smoking, compared to 41 percent of male cancer deaths over age 65. Similarly, for women, 23 percent of deaths under age 65 and 15 percent of those over 65 are attributed to smoking.

To construct a lower bound estimate of the smoking-related attributable risk for cancers, OTA assumed that only lung cancers are associated with smoking. In addition, to account for other possible causes of lung cancer that ACS subjects may not have been exposed to (for example, occupational

Figure 1

Cigarette Consumption & Respiratory Cancer



Source: Office of Technology Assessment
Based on data in Kristein, 1984

exposures, such as to asbestos), OTA doubled the non-smoker rates from the ACS study. The resulting attributable risk estimates for cancer are 33 percent for males under 65, 27 percent for males 65 and over, 15 percent for females under 65, and 8 percent for females 65 and over. The use of these assumptions certainly understates the number of smoking-related cancers and results in an absolute minimum for the estimates of cancer risks. However, the resulting estimate of smoking-related deaths under this very conservative assumption is still very large--about 89,000 deaths or 21 percent of all U.S. cancer deaths.

Using the ACS rates for non-smokers will yield estimates that are too high or too low, depending on how representative the ACS population is of the U.S. population. Officials of the American Cancer Society have suggested to OTA that the death rates for all persons in the ACS study (smokers and non-smokers combined) were 10-20% lower than comparable rates for the entire U.S. population during the years of the ACS study (L. Garfinkle, personal communication, 1985, Garfinkle, 1980). For the American Cancer Society's own estimates of the number of smoking-related deaths, adjustments are made to make the rates from the ACS study more comparable to overall U.S. rates. The resulting estimate is that about 29 percent of all cancer deaths are attributed to smoking (H. Seidman, personal communication, 1985).

OTA's estimates, based on the methods of Doll and Peto, include some adjustment for deaths from esophagus and lip, oral cavity, and pharynx cancers in order to account for the possibility that participants in the ACS study drank alcohol less than the U.S. population average. No other adjustments were made to the Doll and Peto methods, in order to have exactly comparable

estimates.[11] The resulting estimate, using 1982 mortality data, is that 32 percent of cancer deaths are attributed to smoking. The difference of 3 percentage points between the OTA and ACS estimates translates into about 13,000 deaths. Although a substantial number, this represents only about 9 percent of OTA's estimate of 139,000 smoking-related cancer deaths. Moreover, even the ACS estimate of 29 percent is well above the low estimate (described above) of 21 percent that will be used as the lower bound for the cost estimates.

The highest reported estimate for smoking-related attributable risk for cancer is 38 percent (Doll & Peto, 1981, based on tables prepared by Enstrom). An upper bound can be constructed from this estimate. If the 38 percent figure is increased to 40 percent to allow for the increasing share of cancers due to smoking over time, this upper bound is 25 percent greater than the OTA attributable risk estimate of 32 percent. If this is assumed to apply equally to all age and sex groups, then the upper bound estimates are: 63 percent and 51 percent for men under and over 65, and 29 and 19 percent for women under and over 65. These lower and upper bounds are used in the calculation of smoking-related costs.

Chronic Obstructive Lung Disease Deaths

The attributable risks for chronic obstructive lung disease--including emphysema and chronic bronchitis--are calculated using the method employed for

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[11] Doll and Peto considered the possibility that the ACS data would lead to incorrect estimates. They concluded that use of these data result in estimates that are within 10 percent of estimates of the number of smoking-related deaths that can developed using data from several other studies. See discussion in Doll & Peto, 1981, p. 1223.

cancer deaths. The published results of the ACS study (Hammond, 1966) provide age-specific death rates only for emphysema, not all chronic obstructive lung disease. For OTA's estimates, the rates for non-smokers for emphysema from the ACS study were doubled before they were applied to the count of the U.S. population by age and sex in 1982. This allows for deaths from other forms of chronic obstructive lung disease that are related to smoking that were not included under the coding "emphysema." In addition, this doubling allows for the probability that the ACS population did not have large numbers of people with significant occupational exposures (such as to asbestos, silica, coal dust, cotton dust); exposures that can also cause chronic lung disease.

The result of this calculation is an estimate that about 87 percent of chronic obstructive lung disease deaths appears to be related to smoking (Table 6). Table 6 also presents the total number of deaths coded as related to the respiratory system. These include pneumonia, and influenza, as well as chronic obstructive lung disease. While the approximately 52,000 smoking-related deaths from chronic obstructive lung disease represent about 87 percent of all chronic obstructive lung disease deaths, they account for about 48 percent of all deaths from respiratory system disease.

In contrast to smoking-related cancer deaths, the attributable risk for male respiratory system deaths is lower for those under 65 than it is for those 65 and over. The attributable risk for men over 65 is 55 percent, while for those under 65 it is about 46 percent. For women, however, the reverse is true. About 50 percent of respiratory system disease deaths for women under 65 are attributed to smoking, compared to about 38 percent of respiratory system deaths for women over 65.

Table 6
Smoking-related Respiratory System Disease Deaths[1]

United States, Estimates for 1982

	Total Resp. Sys. Deaths (#)	Total Chr.Obs. Lung Dis. Deaths (#)	Smoking-Related (#)	Percent of total Resp. Sys. Deaths
Male - ages under 65	12,160	7,629	6,000	46%
Male - ages 65+	52,867	32,063	29,000	55%
Male - all ages	65,027	39,702	35,000	54%
Female - ages under 65	8,177	4,802	4,000	50%
Female - ages 65+	35,551	15,362	13,000	38%
Female - all ages	43,728	20,167	17,000	40%
Both Sexes - all ages[2]	108,755	59,869	52,000	48%

Source: Office of Technology Assessment

N.B. Estimates of smoking related deaths have been rounded to the nearest thousand.

[1] Based on calculations presented in Appendix Table A-3.

[2] Total for all ages includes deaths recorded without information on age.

All these calculations assume that non-smoker death rates from the ACS study can be applied to the U.S. population. Aside from smoking, the only other significant cause of chronic lung disease is occupational exposure and the ACS population may not have included very many people with these exposures. As already mentioned, non-smokers' rates from the ACS study were doubled to take this into account. Even if the ACS rates are *tripled*, the resulting attributable risk estimate is 83 percent. If, on the other hand, the rates from the ACS study are increased by only 50 percent (to allow only for smoking-related lung disease not reported as emphysema), the attributable risk is 91 percent.

There is evidence that smokers have an increased risk of dying of pneumonia and influenza, but because of the epidemic nature of influenza, it is difficult to estimate precisely the smoking-related fraction for any one year. Thus, even though some of these deaths are related to smoking, they have been excluded from this estimate of the number of deaths associated with smoking.

For the cost analysis presented below, however, the attributable risk estimate based on mortality has been used as an upper bound. Using the attributable risk estimate for mortality leads to estimates of smoking-related health care costs for respiratory system disease costs that are probably too high. One indication of this is that the health care costs per respiratory system death calculated using the mortality attributable risk is several times greater than the cost per death estimated for cancers and heart disease. Probably this is because a large percentage of all health care spending for respiratory system disease involves non-fatal cases of colds and influenza. So for the cost analysis, the attributable risk for respiratory system

mortality is used as an upper bound. The middle estimate and lower bounds were calculated by dividing this upper estimate by 2 and by 4 respectively.[12]

Cardiovascular Disease Deaths

Cardiovascular disease includes both heart disease and strokes. Epidemiologic studies have clearly linked smoking with ischemic heart disease. Death from ischemic heart disease arises from a myocardial infarction, the most common form of fatal "heart attack." Cerebrovascular disease (strokes) is less clearly linked to smoking than the former. In addition, even in the studies that have linked it to smoking, it appears that only in younger age groups (specifically, those under the age of 65) do smokers have significant excess risk of cerebrovascular mortality.

Estimates Using Rates for Non-smokers. Mortality from all cardiovascular disease has been falling for the last few decades: for heart disease rates began falling in the mid-sixties, while for strokes the decline began in the 1940s. It is generally believed that these declines represent the results of a combination of factors, including improvements in diet, decreases in the prevalence of smoking, and changes in medical care. However, the relative importance of these factors is still a matter of debate (see Goldman & Cook, 1984; Pell & Fayerweather, 1985; Walker, 1983; Kleinman, et al., 1979; Kannel, 1982; Staliones, 1980; Gillum, et al., 1984).

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[12] The factors of 2 and 4 are somewhat arbitrary. The resulting middle estimate of the health care costs for smoking-related chronic obstructive lung disease--$6.7 billion (Table 10)--amounts to about $128,000 per chronic obstructive lung disease death. The low estimate of $3.4 billion amounts to about $65,000 per death. These estimates compare to about $50,000 for each cancer death and $65,000 for each circulatory system death.

While of great benefit to the health of the U.S. population, the decline in cardiovascular disease death rates makes more difficult the quantification of the attributable risk of smoking. In short, the heart disease death rates from the ACS study cannot be used directly to generate an "expected" number of cases. Rather, they must be adjusted to take account of declining cardiovascular death rates.

Because of the quantitative uncertainty in the portion of the decline in cardiovascular mortality that can be attributed to the reduction in smoking, a range of adjustments is used here. The general procedure was to take the decline in overall rates from a year near the end of the epidemiologic study (1963 for the ACS study) to 1982. Part of that decline is due to reduced smoking. For example, Goldman and Cook have attributed 24 percent of the decline in coronary heart disease death rates to reductions in smoking. Thus, about 75 percent of the decline is *not* due to reduced smoking. Seventy-five percent of the overall decline can thus be subtracted from the non-smokers' rates from the ACS study to estimate the current rate among non-smokers.[13]

Similar calculations can be made using data from the Framingham Heart Study.[14] Because of the care taken in diagnosis of disease and reporting of information on cause of death for the subjects of this study, the rates for the different subcategories of deaths due to circulatory system disease do not directly correspond to national rates. However, the rates for all

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[13] Appendix Tables A-4 and A-5 present calculations based on the non-smoker death rates for coronary heart disease from the ACS study have been adjusted using assumptions that none, 10%, 25%, and 50% of the overall decline from 1963 to 1982 is associated with the reduced prevalence of smoking.

[14] See Tables A-6 and A-7 of the appendix.

cardiovascular disease are comparable. Thus the death rates for *all cardiovascular disease* for non-smokers are used to calculate an "expected" number of deaths for each sex and age group. These rates are based on the data from the 18-year followup of the Framingham study population. Again an adjustment needs to be made for the changes in cardiovascular mortality rates since that followup. So the rates have been adjusted with the assumption that none, 10%, 25%, and 50% of the decline in total cardiovascular death rates among white males and females since 1968 is associated with reduced prevalence of smoking.[15]

The decline in cardiovascular death rates has not been uniform for all age groups. In fact, younger age groups have had the largest declines. The change in the prevalence of smoking that has probably caused some of this decline has also not been the same for all ages in men and women. Kleinman and colleagues estimate that 15-48 percent of the decline from 1965 to 1976 in heart disease death rates among white men aged 35-44 is due to reduced smoking. For 45-54 year-old white men, their estimates are that 34-42 percent of the decline is associated with reduced smoking, while for 55-64 year-old white men, only 2-18 percent of the decline can be explained by reduced smoking. For women, it is unlikely that very much of the decline in heart disease death rates can be explained by reduced smoking because the prevalence of smoking in women 45 years or older stayed the same or increased from 1965 to 1976 (Kleinman, et al, 1979).

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[15] In addition, as explained in the notes to Table A-6, an adjustment has also been made to correct the Framingham study death rates for 65-74 year-olds.

Thus these calculations should also include the differences by age and sex in the proportion of the decline in cardiovascular mortality that is due to reductions in smoking. For OTA's best estimates, it was assumed that for men aged 35-44 and 45-54, 50 percent of the decline is due to reduced smoking. For men aged 55-64 and 65-74, the assumption is that 25 percent of the decline is associated with reduced smoking. For men aged 75-84, 10 percent of the decline is assumed to be due to smoking reductions. For women of all ages, it was assumed that none of the decline is associated with reduced smoking.[16]

Estimates Using Mortality Ratios and Smoking Prevalence. A second approach for developing attributable risk estimates can also be used. This approach uses the mortality ratio (or relative risk) from the ACS "million person" study and the prevalence of smoking in the U.S. population. The formula[17] for this is:

$$\text{attributable risk} = \frac{b(r-1)}{b(r-1)+1} \times 100$$

In this case, r is the mortality ratio--the ratio of the mortality rate for smokers to the mortality rate for non-smokers, while b is the fraction of the population that are smokers. This formula can be used in cases where there is

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[16] See the notes to Tables A-5 and A-7 of the Appendix. It should be noted that these calculations for heart disease only include persons up to the age of 85. The ACS study did not publish heart disease rates for those over 85. However, as will be discussed later in this paper, mortality ratios for smokers (compared to non-smokers) decline with advancing years as non-smokers eventually die of heart disease. For example, the mortality ratio for those aged 75-84 is 1.2. Thus the implicit assumption that no one over the age of 85 dies of smoking-related heart disease understates these estimates, but probably not to any great extent.

[17] For the derivation of this formula, see, for example, Lilienfeld (1976).

only one risk factor or level of exposure under consideration, for example, when considering only the attributable risk of smoking for current smokers.

However, many in the U.S. population are former smokers. Except for those who have quit because of serious illness, their risk of smoking-related illness is less than that of current smokers, but is still greater than that of non-smokers. To include these former smokers, a modification to the standard formula given above can be made:

$$\text{attributable risk} = \frac{b_0 + (b_1)(r_1) + b_2(r_2) - 1}{b_0 + (b_1)(r_1) + b_2(r_2)} \times 100$$

Here b_0, b_1, and b_2 are the fractions of never smokers, current smokers and former smokers, respectively. The mortality ratios for current smokers and former smokers are represented by r_1 and r_2.[18]

With appropriate data on the prevalence of current smokers, former smokers, and non-smokers in the U.S. population and their mortality ratios, these formulas can be applied. An advantage of using these formulas is that the calculations are not dependent on having reasonably current and representative rates for non-smokers. As discussed above, this is a particular difficulty for developing attributable risk estimates for cardiovascular disease. The disadvantage of the use of these formulas is of finding current and representative mortality ratios. Smokers vary considerably in the amount they smoke, how long they smoke, how deeply they inhale, the kinds of cigarettes they smoke, and the age at which they started

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[18] This formula was provided by D. Rice (personal communication, 1985) and is found in Walter, 1976.

smoking. Former smokers vary in all these dimensions, plus they vary in how long they have given up smoking.

One might try to adjust the mortality ratios from the ACS study or from other studies for the changes that have taken place in smoking habits. Instead of doing this, the calculations using mortality ratios and the prevalence of smoking will simply use the reported mortality ratios from the ACS study for current smokers. If mortality ratios for smokers have risen since the ACS study was conducted, this approach will tend to understate the risk attributable to smoking. The lower bound estimate will be for ischemic heart disease among current smokers only. The upper bound, for this approach, will include former smokers by assuming that their mortality ratios, by age, are the same as those of current smokers. Except for people who are ill and who have recently given up smoking because of their illness, the mortality ratios for current smokers would represent a maximum value for the mortality ratios for former smokers.

The attributable risk percentages fall rapidly with advancing age. For example, about 39 percent of deaths from heart disease among males aged 45-54 can be attributed to smoking by current smokers, while only about 5 percent of heart disease deaths among males aged 75-84 can be attributed to current smoking.[19] This is because both the mortality ratios and the prevalence of smoking decline with age. Only for the younger age groups do the smokers have very large relative risks. As smokers and non-smokers age, the relative risks for heart disease decline, because other causes of heart disease in non-smokers and smokers alike become more important[20].

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[19] Appendix Table A-8 presents these calculations.

[20] The actual rates for heart disease in both smokers and non-smokers continue

Table 7 presents the results of the three different sets of calculations concerning smoking-related cardiovascular disease: calculations using the ACS non-smoker rates, Framingham non-smoker rates, and the ACS mortality ratios. The two estimates using data from the ACS study are both for only deaths from ischemic heart disease.

Ischemic heart disease accounted for 552,786 of the 755,592 U.S. deaths in 1982 from all heart disease. Some of the "other forms of heart disease" that are not included as "ischemic heart disease," such as rheumatic heart disease, are not associated with smoking. But some of the other types of disease that are grouped as "other forms of heart disease," are smoking-related, as are some deaths from other disorders of the circulatory system. Thus, some fraction of deaths coded as due to other forms of heart disease should also be related to smoking. In fact, most of the "other forms of heart disease" reported in NCHS Vital Statistics data are in several miscellaneous categories such as "heart failure" or involve disorders that are often related to general coronary decline associated with ischemic heart disease. These other forms of cardiovascular disease are not included in the estimates for smoking-related ischemic heart disease and thus will tend to understate the number of smoking-related deaths from cardiovascular disease.

In 1982 deaths from heart disease represented 755,592 or the 967,868 deaths from cardiovascular disease. The difference consists of about 160,000 deaths from cerebrovascular disease ("strokes"), 20,000 deaths from causes associated with the arteries and the peripheral circulatory system, and about

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to rise as they age. Appendix Table A-9 presents the application of these attributable risks to estimate the number of smoking-related deaths from ischemic heart disease.

Table 7

Smoking-related Heart Disease Deaths[1]

United States, Estimates for 1982

Sex & Age Group (percent of cardiovascular deaths in parentheses)	Total cardio-vascular deaths[2] (#)	Total Heart Disease Deaths[3] (#)	Using ACS non-smoker rates: Smoking-related Deaths[4] (#)	Using Framingham non-smoker rates: Smoking-related Deaths[2] (#)	Using ACS mortality ratios & HIS smoking prevalence: Current Smokers only: Smoking-related Deaths[4] (#)	Using ACS mortality ratios & HIS smoking prevalence: Maximum Current & Former Smokers Combined: Smoking-related Deaths[4] (#)
Male - ages under 65	129,994	113,979	46,000 (36%)	37,000 (29%)	25,000 (19%)	39,000 (30%)
Male - ages 65+	359,064	284,490	44,000 (12%)	47,000 (13%)	12,000 (3%)	34,000 (9%)
Male - all ages	489,179	398,570	90,000 (18%)	84,000 (17%)	37,000 (8%)	72,000 (15%)
Female - ages under 65	57,485	44,813	20,000 (34%)	23,000 (41%)	6,000 (10%)	8,000 (14%)
Female - ages 65+	421,104	312,134	33,000 (8%)	15,000 (4%)	5,000 (1%)	11,000 (3%)
Female - all ages	478,689	357,022	52,000 (11%)	39,000 (8%)	11,000 (2%)	19,000 (4%)
Both sexes - all ages[5]	967,868	755,592	142,000 (15%)	123,000 (13%)	48,000 (5%)	91,000 (9%)

Source: Office of Technology Assessment

N.B. Estimates of smoking related deaths have been rounded to the nearest thousand.

[1] Based on calculations presented in Appendix Tables A-4 to A-9.
[2] Major cardiovascular diseases (I.C.D. 390-448).
[3] Diseases of the heart (I.C.D. 390-398, 402, 404-429).
[4] Ischemic heart disease only (I.C.D. 410-414)
[5] Totals for all ages include deaths reported without information on age.

25,000 deaths reported as due to "atherosclerosis." To the extent that these were associated with smoking in the Framingham study population, they will be included in the estimates based on the Framingham non-smoker rates. Thus the estimates based on the Framingham rates for cardiovascular disease represent the most comprehensive calculation of smoking-related circulatory system disease deaths.

The range in Table 7 of smoking-related cardiovascular disease deaths is from 48,000 to 142,000. Both of these estimates include only deaths from ischemic heart disease and thus will understate the total. In addition, the 48,000 death figure only includes current smokers and thus represents a minimum estimate of the smoking-related toll. Although the 148,000 death figure (using the ACS non-smoker rates) will be an underestimate because it includes only ischemic heart disease, it may be an overestimate because the death rates from the ACS study tended to be lower than overall U.S. rates. The American Cancer Society's estimate is that about 11 percent of all cardiovascular disease deaths are attributable to smoking--about 110,000 deaths using 1982 mortality data. This figure of 110,000 is relatively close to the estimate of 123,000 deaths that derives from the data of the Framingham study.

The 1983 report of the Surgeon General states that "up to 30 percent of all CHD [coronary heart disease] deaths in the United States are attributable to the cigarette smoking habit" (U.S. DHHS, 1983, p. 65). The source for this estimate is credited to a document prepared jointly by the National Cancer Institute and the National Heart, Lung, and Blood Institute (U.S. DHHS, 1977). That document presents a table listing attributable risk estimates for heart disease, arteriosclerosis, bronchitis/emphysema, and cancers of the oral

cavity, esophagus, pancreas, larynx, trachea, kidney, and bladder. However, the document provides no details of the calculations or assumptions behind these estimates.

The estimates presented in Table 7, from 48,000 to 142,000 smoking-related deaths are still very large totals, even if they are less than the Surgeon General's estimate of 170,000. The cost calculation presented below will use both extremes. At the lower bound will be the figure of about 48,000 deaths or an attributable fraction of about 5 percent of all circulatory system disease. At the upper end of the estimates for smoking-related disease is the figure of 170,000 heart disease deaths, which is equal to about 18 percent of cardiovascular disease deaths. The distribution of these deaths between men and women and between those under 65 and those 65 and over, will be made using the same percentage distribution as that calculated by using the rates for non-smokers from the ACS study.[21] The "middle estimate" for the calculation of costs will be the midpoint between these two extremes.

While this range of between 5 percent and 18 percent is large, we can be reasonably sure that the true value lies somewhere in between. In the calculation of the years of life lost from smoking-related heart disease, the "middle estimate," based on the Framingham data, of 123,000 deaths or about 13 percent of cardiovascular disease deaths will be used for the total number of heart disease deaths and the age distribution of those deaths.[22]

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[21] Specifically, 54,000 smoking-related deaths among men under 65 (42 percent of cardiovascular disease deaths), 53,000 for men 65 and over (15 percent), 24,000 for women under 65 (41 percent), and 39,000 for women 65 and over (9 percent).

[22] This figure of 13 percent is slightly less than a preliminary estimate, prepared for the Carter Center and Centers for Disease Control, that about 15 percent of cardiovascular disease mortality can be attributed to smoking (C. White, Centers for Disease Control, personal communication, 1985).

Summary of OTA Estimates of Smoking-related Deaths

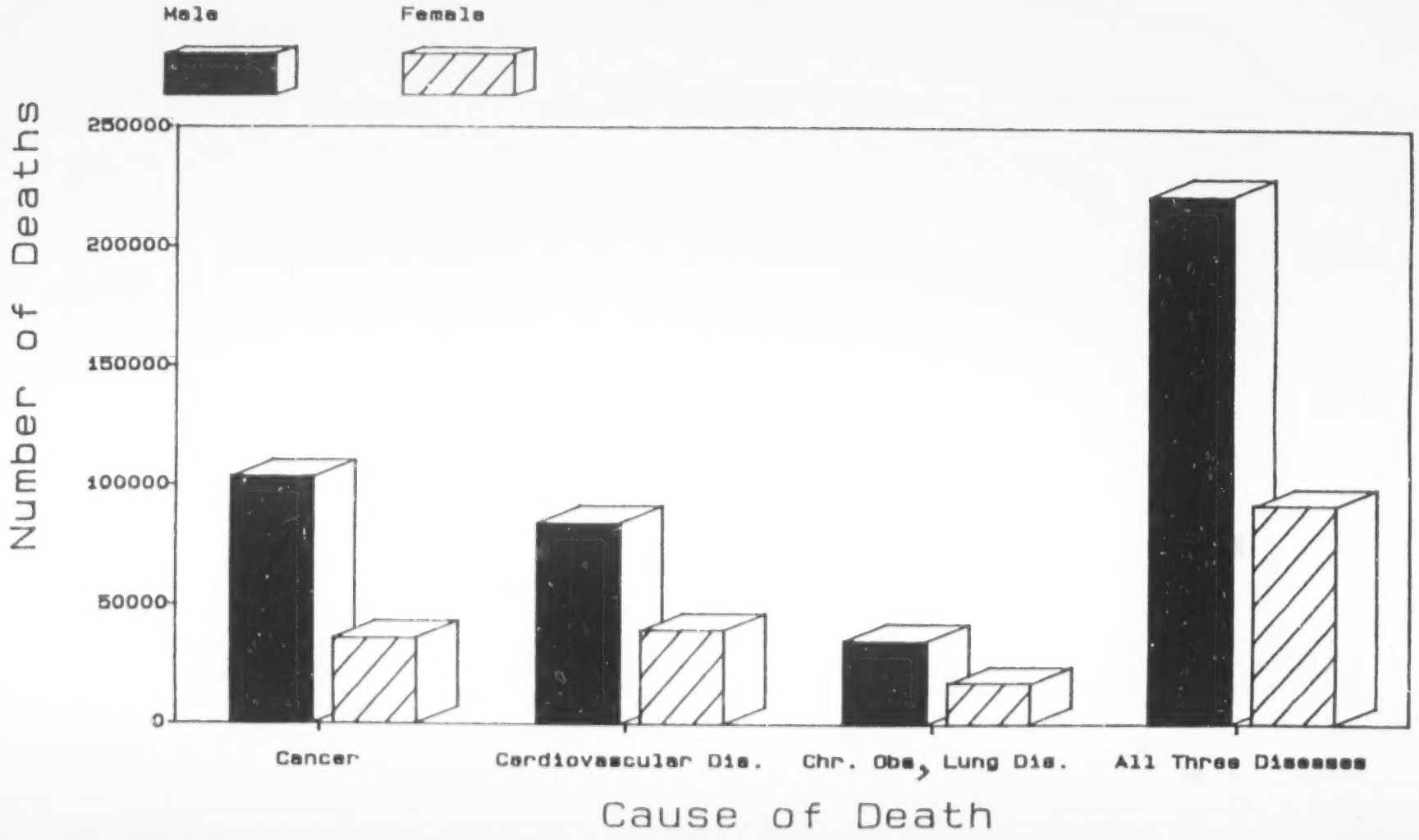
OTA's middle estimates of the number of smoking-related deaths in 1982 are 139,000 deaths from cancer, 123,000 from cardiovascular disease, and 52,000 deaths from chronic obstructive lung disease. The total for these three causes of death is 314,000. These amount to 32 percent of cancer deaths, 13 percent of cardiovascular deaths, 88 percent of chronic obstructive lung disease deaths, and 16 percent of deaths from all causes. The range of the estimated smoking-related toll from these three causes is from a minimum of 186,000 deaths to 398,000 deaths. As noted above, OTA's estimates focus on only the three major causes of smoking-related death. This tends to understate the toll of smoking because other causes of death and illness, such as ulcers or perinatal problems due to smoking during pregnancy, have been excluded from this analysis.

Figure 2 summarizes OTA's middle estimate by sex. As is readily apparent from the Figure, the current toll of smoking-related disease strikes men much more frequently than women. About 70 percent of smoking-related deaths in 1982 occurred among men. This is because men, in the past, were smokers more frequently than women, generally smoked a greater number of cigarettes, and generally inhaled more deeply than did women smokers. Unfortunately, while smoking rates for men have been declining during the last decade, smoking rates among several age groups of women have been increasing. These changes will be reflected in death rates in the future.

Life-years Lost and Probability of Early Death

Table 8 presents the number of life-years lost due to smoking-related

Figure 2
Smoking-Related Deaths
By Sex



Source: Office of Technology Assessment

Table 8

Years of Life Lost from Smoking-related Premature Mortality[1]

Summary

Disease Sex & Age Group	Estimated Deaths to Smokers (#)	Estimated Years of Life Lost: Using ave. years of life remaining for smokers & non-smokers combined	Estimated Years of Life Lost: Using ave. years of life remaining for non-smokers only	Estimated Years of Life Lost: Using ave. years of life remaining before age 65
Cancers				
Total Male	103,000	1,461,000	1,623,000	348,000
Total Female	36,000	684,000	724,000	147,000
Total Cancer Deaths	139,000	2,145,000	2,347,000	494,000
Cardiovascular Disease				
Total Male	84,000	1,269,000	1,413,000	394,000
Total Female	39,000	855,000	903,000	282,000
Tot. Cardiovascular Deaths	123,000	2,125,000	2,317,000	676,000
Chronic Lung Disease				
Total Male	35,000	368,000	399,000	36,000
Total Female	17,000	260,000	274,000	32,000
Total Chr. Obs. Lung Dis.	52,000	627,000	674,000	67,000
TOTAL -- All Three Diseases	314,000	4,896,000	5,338,000	1,237,000
Ave. years lost per death		16	17	4

Source: Office of Technology Assessment

N.B. Estimates of smoking related deaths have been rounded to the nearest thousand.

[1] Based on calculations presented in Appendix Table A-10.

disease for each of the three major disease categories discussed above. The total life-years lost are calculated using two different estimates of the number of years of expected remaining life.

The first estimate is based on data for the entire U.S. published by the National Center for Health Statistics. These data on average life expectancy at given ages include both smokers and non-smokers and, thus, tend to underestimate the number of years remaining for non-smokers. The second estimate uses unpublished life table data from the ACS million person study that distinguishes the life expectancy of non-smokers from that of smokers. Using these data, the estimated number of life-years lost increases from about 4.9 million to 5.3 million, an increase of nearly 10 percent.

The last two columns of Table 8 present the number of life-years lost before the age of 65--years that are generally spent as part of the productive labor force. These total to an annual toll of about 1.2 million years lost before age 65.[23]

From a public health standpoint, the number of deaths and life-years lost are probably the most important statistics for evaluating the impacts of smoking. From a more personal standpoint, for individual smokers, the chances of dying prematurely are probably more meaningful. Table 9 presents an abbreviated life-table to illustrate these probabilities. In this table, the calculations start with 100 male and female, smokers and non-smokers, at age

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[23] The procedure used to calculate life-years lost is based on the number of years remaining for the midpoint of each ten-year age group. Thus, for 45-54 year-olds, the number of years remaining for 50 year-olds was used. Because deaths occur more frequently in the later years of a ten-year age group, when compared to the earlier years, this method will lead to a small overstatement of the number of life-years lost.

Table 9

Percentage surviving to particular ages
Smokers versus non-smokers[1]

Age	Male Non-smokers	Male Smokers[2]	Female Non-smokers	Female Smokers[2]
35	100	100	100	100
40	99	99	99	99
45	98	96	99	98
50	97	93	98	96
55	95	88	96	93
60	91	80	94	89
65	85	70	90	83
70	76	56	85	75
75	64	41	76	63
80	47	25	62	48
85	28	12	43	30
90	13	9	23	15

Source: From unpublished lifetable calculations by E. Lew, based on data from the American Cancer Society "million person" study.

[1] Starting with 100 persons alive at age 35, this table presents the estimated number who survive to the ages given.

[2] Smokers of one or more packs per day.

35. Each line of the table presents how many of the original group of 100 have survived to the indicated age. Thus, of 100 male 35 year-old non-smokers, 85 will live at least to age 65, while 64 will live at least to 75. For male smokers, only 70 will live to age 65 and 41 will live to age 75. Put another way, a male non-smoker at age 35 has a 15 percent chance of dying before age 65, while a male smoker has a 30 percent probability--a doubled risk of dying before age 65.

The table also presents data for female smokers and non-smokers. These data show less of a difference between smokers and non-smokers than the data for men. This is probably due to the lower intensity of smoking among the female smokers who were part of the ACS study which was conducted during the late 1950s and early 1960s. As women have begun to smoke much more like men, their chances of dying prematurely will increase.

Doll and Peto have suggested that public education about the effects of smoking ought to include quantitative information. The main message is simple: "About a quarter of all regular cigarette smokers will be killed before their time by the habit." They also suggest a comparison with other causes of death. In the U.S., during the lifetime of 100 young adults who smoke cigarettes regularly, 1 will be murdered, 2 will be killed in traffic collisions, and 25 will be killed by tobacco (Doll & Peto, 1985).

Smoking-related Disease Costs

Once attributable risk estimates have been developed, the next step is to estimate the financial costs of smoking. For these estimates, OTA is employing the method most commonly used in previous estimates of the costs of

smoking. This method apportions direct health care costs and indirect productivity costs using estimates of the attributable risks for smoking-related mortality. The major assumption here is that the proportion of costs attributable to smoking is equal to the proportion of deaths related to smoking in each disease category. Thus, it is assumed that if 32 percent of all U.S. cancer deaths are associated with smoking, then 32 percent of the health care costs for treating cancer are also associated with smoking. This is an important assumption that should be explored in future research on the costs of smoking. However, answering this question would require extensive data collection that is beyond the scope of this OTA Staff Memorandum.[24]

Table 10 presents the estimates of smoking-related health care costs for 1985, using the range of attributable risk estimates discussed in the previous section. The original data for the costs of care for each major disease category for men and women over and under the age of 65 are from Hodgson and Kopstein (1984). Their figures for 1980 have been inflated to 1985 values using the increase in personal health care costs, by type of spending, that is implied in the estimates of National Health Expenditures developed by the Health Care Financing Administration (Gibson, Levit, Lazenby, & Waldo, 1984).

Using the data for 1985, the total health care costs of smoking-related disease amount to between $11 and $35 billion or from 3 to 9 percent of total U.S. health care spending. The middle estimate is about $22 billion or about

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[24] Some research is already taking place on this. For example, Rice & Hodgson are analyzing data from the National Health Interview Survey in order to develop attributable risk estimates based on morbidity differences between smokers and non-smokers.

Table 10

Smoking-related Health Care Costs
All Ages, Estimates for 1985

Summary[1]

Disease	Total under 65 ($ mil)	Total 65 & over ($ mil)	Total all ages ($ mil)
Cancers			
Low Estimate	2,900	1,600	4,400
Middle Estimate	4,400	2,500	6,900
High Estimate	5,500	3,100	8,700
Circulatory system diseases			
Low Estimate	3,100	600	3,700
Middle Estimate	5,800	2,200	8,000
High Estimate	8,700	3,800	12,500
Respiratory system diseases			
Low Estimate	2,500	800	3,400
Middle Estimate	5,000	1,600	6,700
High Estimate	10,000	3,300	13,400
Total - Three Disease Groups			
Low Estimate	8,500	3,000	11,500[2]
Middle Estimate	15,200	6,400	21,600[2]
High Estimate	24,300	10,200	34,500[2]

Source: Office of Technology Assessment

N.B. Estimates of smoking related costs have been rounded to the nearest one hundred million dollars.

[1] Based on estimates of the fraction of 1982 mortality attributable to smoking applied to estimates of 1985 personal health care costs. Use of the 1982 attributable risks will probably understate actual costs in 1985 because the highest smoking cohorts are still at ages when smoking-related deaths occur. Appendix Table A-12 presents details of the calculations for this summary table. Appendix Table A-11 presents estimates using estimated health care costs for 1982.

[2] Estimate for 1985 for all diseases is $372.8 billion. Thus, the low, middle, and high estimates of smoking-related costs equal 3%, 6%, and 9% of this total.

6 percent of all U.S. health care spending.[25] This estimate includes $6.9 billion for cancers, $8 billion for circulatory system disease, and $6.7 billion for respiratory system disease. Nearly three-fourths of these estimated costs ($15.2 billion) are incurred by those under the age of 65.

For calculating the costs to government programs, OTA included only costs to programs that provide personal health care for those 65 and over. To calculate government program costs, the estimated costs of each disease category and type of service for those over 65 are multiplied by the estimated fraction of that type of service that is paid for by the particular government program. Excluded from these calculations are expenditures through the Medicare and Medicaid programs for medical treatment to those under the age of 65. Social Security disability insurance and other government programs also provide income support for some persons unable to work due to smoking-related disease. These costs may be substantial, but they have also been excluded from this analysis. In both cases, these exclusions will lead to an underestimate of the total costs of smoking to government programs.

The results, for the entire range of attributable risk estimates for those 65 and over, are presented in Table 11. OTA estimates that the annual smoking-related costs to the Medicare program amount to between $1.7 and $5.4 billion. The Medicaid program bears costs between $0.3 and $1.1 billion, while other government programs (mostly the health services provided by the Veterans' Administration) incur costs of between $0.2 and $0.6 billion. The

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[25] A preliminary estimate by Rice & Hodgson for smoking-related costs for cancers, circulatory system disease, and respiratory disease, using *morbidity* data from the National Health Interview Survey is about $23 billion in 1984 dollars. This is close to OTA's middle estimate of about $22 billion in 1985 dollars, which is based on *mortality* attributable risks.

Table 11

Smoking-related Government Costs
for providing personal health care

Summary of Estimates for 1985[1]

Disease	Attributable Risk Male (ages 65+)	Attributable Risk Female (ages 65+)	Medicare ($ bil.)	Medicaid ($ bil.)	Other Pgm. ($ bil.)	Total ($ bil.)
Cancers						
Low Estimate	27%	8%	1.0	.1	.1	1.2
Middle Estimate	41%	15%	1.5	.2	.2	1.9
High Estimate	51%	19%	1.9	.2	.2	2.3
Circulatory Sys. Disease						
Low Estimate	3%	1%	.3	.1	.0	.4
Middle Estimate	9%	5%	.9	.4	.1	1.4
High Estimate	15%	9%	1.6	.6	.2	2.4
Respiratory Sys. Disease						
Low Estimate	14%	10%	.5	.1	.1	.6
Middle Estimate	28%	19%	.9	.1	.1	1.2
High Estimate	55%	38%	1.9	.2	.2	2.3
Total - Three Disease Groups						
Low Estimate			1.7	.3	.2	2.1
Middle Estimate			3.4	.7	.4	4.4
High Estimate			5.4	1.1	.6	7.1

Source: Office of Technology Assessment

[1] Based on calculations presented in Appendix Table A-13. Government program cost estimates are only for persons aged 65 and over.

total for these programs is between $2.1 and $7.1 billion. The middle estimate is $4.4 billion.

The Medicaid program is jointly financed by the Federal Government and the states.[26] Thus, the Federal share of the estimated Medicaid costs for smoking-related disease amounts to about 54 percent of $0.3 and $1.1 billion or between $0.2 and $0.6 billion. Subtracting this range from the total government costs in Table 20 gives a range of $2.1 to $6.6 billion as the estimated burden on the Federal budget of paying for the treatment of smoking-related disease. The middle estimate for Federal health care costs is $4.2 billion.

Table 12 presents estimates of the costs of lost productivity from smoking-related morbidity and mortality. These have been calculated using the attributable risk estimates and data on the lost earnings associated with broad disease categories. Lost earnings have been used in many cost-benefit analyses to represent the "value of life." As has been pointed out, lost earnings are really a measure of the value of livelihood, not of life. People who are retired, for example, still attach value to their lives. They and society are still willing to pay for life-saving programs.[27] The value of lost earnings is not included here to indicate the value of preventing smoking-related disease. Rather, these estimates are included as minimum values of the losses experienced by society because of reduced economic

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[26] In 1983, Medicaid was estimated to have paid $35.6 billion for personal health care services. Of this $19.2 billion (54 percent) was paid by the Federal government, and $16.4 billion (46 percent) was paid by state and local governments (see Table 10, in Gibson, Levit, Lazenby, & Waldo, 1984).

[27] This "willingness to pay" is probably substantially larger than the value of lost earnings. Nevertheless, there are significant technical and conceptual difficulties in developing estimates of this "willingness to pay." See OTA, 1980, OTA, 1985.

Table 12

Smoking-related Lost Productivity Costs

All Ages, Estimates for 1985

Summary[1]

Disease	Total under 65 ($ mil)	Total 65 & over ($ mil)	Total all ages ($ mil)
Cancers			
Low Estimate	11,500	900	12,400
Middle Estimate	17,500	1,400	18,900
High Estimate	22,000	1,700	23,800
Circulatory system diseases			
Low Estimate	9,800	200	10,000
Middle Estimate	16,600	800	17,400
High Estimate	24,100	1,400	25,400
Respiratory system diseases			
Low Estimate	4,100	500	4,600
Middle Estimate	6,400	700	7,100
High Estimate	10,300	1,000	11,300
Total - Three Disease Groups			
Low Estimate	25,300	1,600	26,900
Middle Estimate	40,500	2,900	43,400
High Estimate	56,400	4,100	60,500

Source: Office of Technology Assessment

N.B. Estimates of smoking-related costs have been rounded to the nearest one hundred million dollars.

[1] Based on estimates of the fraction of 1982 mortality attributable to smoking applied to estimates of lost earnings inflated to 1985 dollars. Use of the 1982 attributable risks will probably understate actual losses in 1985 because the highest smoking cohorts are still at ages when smoking-related deaths occur. Appendix Table A-15 presents details of the calculations for this summary table. Appendix Table A-14 presents estimates using estimated lost productivity costs for 1982.

productivity arising from smoking-related illness and premature death.

Table 12 shows a range of from $27 billion to $61 billion for the costs of smoking-related lost productivity. The middle estimate is about $43 billion. As can be expected, most of these losses occur from deaths to those under the age of 65.

Thus OTA's estimates are that the Nation will incur in 1985, between $12 and and $35 billion in smoking-related health care costs, and from $27 to $61 billion in lost productivity costs. OTA's middle estimate is about $22 billion in health care costs and $43 billion in lost productivity costs. Currently, about 30 billion packs of cigarettes are sold each year in the U.S. Thus the total health care costs attributable to smoking equal about 72 cents for each pack, while the lost productivity equal $1.45 per pack. The total of the middle estimates of both health care and productivity costs is about $65 billion or about $2.17 per pack.

The estimated Medicare costs of $3.4 billion are equal to about 11 cents per pack, while Medicaid costs of $0.7 billion equal 2 cents per pack. The total for Federal health care programs is about $4.2 billion, or about 14 cents per pack. The estimated range of Federal program costs is from $2.1 billion to $6.6 billion. Even the low estimate of this range translates into 7 cents per pack, while the high estimate of this range equals 22 cents per pack.

U.S. health care expenditures are paid for privately by individuals and their families, by health insurance plans, and by government programs such as Medicare and Medicaid. Many have suggested that a large portion of health care costs associated with smoking are, in fact, borne by non-smokers. Similarly, a portion of the smoking-related lost productivity costs may be

borne by non-smokers. Warner (1982) estimated that aproximately $15 billion (about 38 percent) of the estimated $40 billion in smoking-related social costs (in 1980 dollars) was borne by smokers, either directly or through their share of insurance and tax payments. The remaining $25 billion (or about 62 percent) was estimated to be the share of smoking-related costs borne by non-smokers.

On the other hand, it is not entirely clear that non-smokers subsidize smokers' ill health. Government programs, taxation, and the health insurance and medical care systems set up an extensive network of subsidies between those who use services and those who contribute to them. Thus the issue of who bears the medical care and lost productivity costs of smoking is a complex one and is therefore not addressed in this Staff Memo.

FUTURE COSTS IF SMOKING IS REDUCED

A number of studies have shown that except for those who quit because of a serious illness, those who stop smoking have improved life expectancy compared to those who continue to smoke. With each year of non-smoking, the ex-smoker's relative risk of death declines.

Those who never smoke have the lowest mortality rates for the various smoking-related diseases. Measures that reduce the chances that people will ever start smoking, will have the greatest impact on longevity and death rates. Of course the health benefit of fewer people initiating the smoking habit in 1985 will not be realized until years in the future. For example, most twenty year-olds who start smoking today will not experience smoking-related premature mortality until their forties, fifties, and sixties.

Similarly, the benefits of improved health for twenty year-olds dissuaded from the cigarette habit today will not be seen in death rates until 20 to 40 years from now. Although real, improvements in health due to reduced smoking will not be immediate.

At the present time, it is clear that large sums are spent treating smoking-related disease. The method of OTA's estimates apportions health care costs based on the attributable risk for smoking-related mortality. The method of calculating the deaths attributable to smoking, in effect, subtracts out the deaths that would have occurred even in the absence of smoking. Thus the deaths can be considered "excess deaths"--deaths that would not have occurred in 1982 but for the use of tobacco products. If the assumption that costs can be apportioned based on mortality is accepted, then the costs attributable to these "excess deaths" are "excess costs."

It is a perverse, but real fact of life, however, that elimination of smoking could lead to future increases in total medical spending, in the costs of the Medicare program, and in the budgets of the Social Security program and other government programs. Some researchers have attempted to estimate the effects that the reduction or elimination of smoking would have on medical care spending and the size of a nation's population. This research is still in its infancy; there are still many obstacles to overcome in making estimates of the effects of reduced smoking.

Empirically, it is still not clear exactly what effect reduced smoking will have on future health care costs. There is much conjecture in this area and not very much data. In addition, it is not completely clear that is it appropriate to consider the effects of reduced smoking on health care spending as "costs" when evaluating the effects of preventive programs. Instead, many

argue that the focus should be on the reductions in disease and the increases in longevity that would result from reduced smoking.

Moreover, health care costs are not determined solely by the size of the population or the diseases they suffer from. Even if a reduction in smoking leads to changes in the size and age of the population and their demand for medical services, society will still face the question of how much to spend on medical care and for what uses. It must also be remembered that better health and extended longevity would accompany the speculated increase in health care costs that might result from a reduction in the prevalence of smoking.

Atkinson and Townsend estimated the effects that a reduction in smoking would have on the British National Health Service and budget of the British government. Reduced smoking would reduce the need for hospital beds and would temporarily reduce the number of outpatient visits to doctors. Over time, however, as the non-smokers aged, the number of physician visits would increase. In addition, there would be reductions in the government's costs of providing sickness benefits and widows' benefits, but increases in the costs of providing retirement pensions (Atkinson & Townsend, 1977).

Leu and Schaub used a computer model that simulated a hypothetical Swiss male population under the assumption that no one had smoked during the century from 1876 to 1976. They compared the estimated medical care spending in 1976 for this hypothetical population with actual expenditures in 1976 and found little difference between the estimated spending totals for these two populations. The major difference was that the hypothetical non-smoking population was larger and older than the actual population. According to Leu and Schaub, the lower annual medical care use by non-smokers between age 35

and 84, was almost exactly offset by the predicted increase in overall spending that resulted from the increase in the size of the population and the increase in percentage of the population in the older age groups (Leu & Schaub, 1983).

Gori and Richter have also pointed to the potential increase in the size of the population over the age of 65 that would accompany the reduction in the number of tobacco-related disease deaths. In addition, they have attempted to estimate some of the other macroeconomic effects that successful disease prevention programs might have. (Gori & Richter, 1978; Richter & Gori, 1980).

It must be emphasized that these findings are still very speculative and based on a number of assumptions concerning the health care system, medical utilization, disease incidence, mortality, and the financing of health care and Social Security. It is also important to keep in mind that with additional spending, we will probably also be gaining additional years of life. If the Leu and Schaub conclusion is correct that elimination of smoking would lead to an increase in the size of the population but with essentially the same total medical care spending, then this also means that per capita spending has declined. Provided the average health of this larger population is the same or better, this would imply that society is receiving more health for its health care dollars.

One very important factor in any discussion of future health care costs if smoking is reduced concerns the time pattern of the costs. Specifically, costs in future years should be made comparable to costs in the present by *discounting* them with an appropriate interest rate. If the effect of reduced smoking is to lead to a shifting into the future of the major medical expenses

associated with a person's last set of illnesses, then these expenses should be discounted. It could be that medical care expenses incurred by smokers and non-smokers are exactly the same in the year of treatment. But even if this is true, the non-smokers' expenses are incurred, on average, over a longer period of time and in later years. If these expenses are then discounted to express them as *present values*, the expenditures for the non-smoker will be less than those for the smoker.[28]

A reduction in smoking will lead to reductions in the costs for treating smoking-related disease, while possibly leading to increases in costs in future years for for treating the additional people alive. But even if this is true, however, a preliminary analysis by Lewit has pointed out that substantial savings in health care costs may be achieved during the time it takes to move between these two states. During that time period health care costs will be less than what they would have been if smoking had not been reduced (Lewit, 1983).

Future trends in the use of medical technology and changes in government and third-party reimbursement will clearly affect future costs. Predicting the extent of these changes and their effects is difficult. New, more expensive technologies may become more widely used. In this discussion of smoking-related disease, it should be noted that all of the patients who have received the experimental artificial heart had been smokers.[29]

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[28] One major criticism of the Leu and Schaub study is that they did not analyze the effects that discounting would have on their results.

[29] Ravenholt estimates that each of these patients had smoked more than 250,000 cigarettes during his lifetime (Ravenholt, in press).

From the standpoint of the Social Security and Medicare programs, reduced smoking may lead to increased program costs. Changes in Social Security spending are not, strictly speaking, economic costs because Social Security is an income transfer program. Nevertheless, potential changes in the number of beneficiaries need to be considered. The extent of these changes and the effects they might have on the financing of Social Security are less clear. This increase may require changes in the financing of the Social Security system, which is based on a number of assumptions concerning population size, employment, inflation, etc. On the other hand, reductions in smoking will also increase the size of the employed population as well, and thus increase revenues provided to the Social Security and Medicare trust funds. The change in the elderly population due to reduced smoking is not an assumption that will "surprise" us. Rather, reduced smoking and the accompanying reduction in disease are likely to occur gradually, giving us time to plan for these changes.

Reductions in smoking will also be accompanied by reduction in the sales of cigarettes and declining demand for tobacco. This could create important economic dislocations as well as reductions in Federal and state tax revenues that are associated with the production and sales of tobacco and tobacco products.[30]

Of course, from a narrow vantage point that considers only the finances of the Social Security and Medicare systems, we should all die the day before we retire. This is not an acceptable basis for public health policy. More generally, many would argue that it is inappropriate to consider the potential

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[30] How these dislocations and adjustments can be ameliorated is an important issue for government policy, but is beyond the scope of this Staff Memorandum.

future health care costs avoided by unnecessary premature deaths. On the other hand, even though the reduction of smoking-related disease may not lead to medical cost savings, it will lead to large gains in productivity as people who would have died before age 65 continue to work until the normal age of retirement.

Elimination of smoking might not result in reductions in total medical spending or in the costs of the Medicare program. However, a policy to reduce the costs of the Medicare system by allowing hundreds of thousands of preventable smoking-related deaths to occur each year is contrary to ethical standards and the principles of the U.S. health care system. In any event, this Staff Memorandum has not attempted to quantify these hypothetical impacts and costs. Instead, the focus has been on the real costs incurred today--costs that will continue into the future barring significant changes in the sales and consumption of tobacco products.

Rather than discussing changes in costs or financing programs, it is more important to focus instead on the improvements in health, longevity, and overall quality of life that would accompany reduced smoking. Measures to reduce smoking might lead to large improvements in longevity for relatively modest expenditures. Thus, as Warner has pointed out, reduction in smoking may be a cost-*effective* way of improving health, even if it does not prove to be cost-*saving* (Warner, 1984). Hypothetical future health care or pension program costs do not, in the end, provide an excuse for less than the most enthusiastic effort to eliminate premature and preventable death and disease through reduction and elimination of smoking.

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